PERFORMANCE OF ULTRA HIGH PERFORMANCE CONCRETE BY USING PALM OIL CLINKER AS PARTIALLY AGGREGATE REPLACEMENT

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Industri pembinaan semakin berkembang dari hari ke hari. Keperluan konkrit dalam bidang ini semakin meningkat dan perkembangannya dalam industri konkrit telah bertambah baik apabila terdapat beberapa jenis konkrit baharu iaitu konkrit berprestasi tinggi dan konkrit berpretasi ultra tinggi. Konkrit berprestasi ultra tinggi (UHPC) adalah salah satu jenis konkrit yang mempunyai ciri-ciri mekanikal yang cemerlang dan mempunyai katahanan yang baik dibandingkan dengan konkrit biasa. Walau bagaimanapun, konkrit jenis ini mempunyai beberapa batasan dari segi kos pengeluaran dan ketersediaan bahan mentah. Penghasilan UHPC memerlukan sejumlah besar simen, pasir dan batu. Pengunaan klinker minyak kelapa sawit sebagai separa pengganti aggregat dapat mengurangkan masalah yang timbul akibat penghasilan UHPC. Penggunaan klinker minyak kelapa sawit dalam kajian ini telah dirangsang daripada masalah alam sekitar yang timbul akibat pembuangan sisa indutri minyak kelapa sawit dan penghasilan aggregat semula jadi. Dalam kajian ini, ciri-ciri mekanikal bagi UHPC menggunakan klinker minyak kelapa sawit (POC) sebagai pengganti aggregat sebahagiannya telah disiasat. Empat (4) tahap peratusan berbeza POC sebagai pengganti aggregat kasar telah disediakan. 0%, 5%, 10% dan 15% POC daripada jumlah aggregat kasar digunakan. Specimen yang dilebelkan sebagai UHPC biasa mempunyai sebanyak 0% penggantian POC, manakala untuk konkrit yang mengandungi 5%, 10% dan 15% penggantian POC dilabelkan sebagai POC-UHPC5, POC-UHPC10, dan POC-UHPC15. Ujian kemusnahan dilakukan pada konkrit baru manakala ujian kekuatan mampatan dan ujian kekuatan lenturan dilakukan kepada konkrit yang keras. Ujian kemusnahan dilakukan sejurus selepas konkrit dibancuh dan ujian mampatan dan kekuatan lenturan diuji selepas 7, 28 dan 60 hari direndam didalam tangki air. Keputusan eksperimen menunjukkan pengurangan kekuatan mampatan dan kekuatan lenturan terhadap kesemua UHPC specimen yang mengandungi POC sebagai penggantian aggregat. Ia mendedahkan bahawa peningkatan peratusan POC menjurus kepada penurunan kekuatan mampatan dan kekuatan lenturan terhadap specimen. Secara keseluruhan, pengunaan 10% POC sebagai pengganti aggregate menunjukkan hasil yang sama dari segi kekuatan mampatan dan kekuatan lenturan konkrit.

ABSTRACT

Construction industry has been growth from day to day. The requirement of concrete in this field has been increasing and the development in concrete industry has been improve when there is a new type of concrete which is high performance concrete and ultra-high performance concrete. Ultra-high performance concrete (UHPC) is a one of concrete type that has outstanding mechanical properties and a good durability as compared to normal concrete. However, this type of concrete has some limitation in terms of production cost and availability of raw materials. The production of UHPC, require the large amount of cement, sand and coarse aggregate. The use of palm oil clinker as partial aggregate replacement can reduce the problem arising due to the production of UHPC. The use of palm oil clinker in this study was stimulated from the environmental problem issue arising due to the disposal of palm oil industry waste and the production of natural aggregate. In this present study, the mechanical properties of UHPC incorporating with palm oil clinker (POC) as partially replacement of aggregate was investigate. Four (4) different percentage level of POC as partial replacement of coarse aggregate was prepared. 0%, 5%, 10%, and 15% of POC from the total of coarse aggregate were used. The specimens was label as plain UHPC with 0% of POC replacement, while for the concrete contain 5%, 10% and 15% POC replacement were label as POC-UHPC5, POC-UHPC10 and POC-UHPC15. Slump test was conduct on fresh concrete while compressive strength test and flexural strength test for hardened concrete. Slump test was conduct immediately after the mix and compressive strength test and flexural strength was tested after 7, 28 and 60 days of curing in water tank. The experimental result shows the reduction of compressive strength and flexural strength of UHPC contains POC as aggregate replacement specimens. It was revealed the increasing percentage of POC lead to decreasing the compressive strength and flexural strength of the specimens. Overall, the use of 10% POC as partial aggregate replacement show similar result on both compressive strength and flexural strength of the concrete.

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LIST OF SYMBOLS

MPa	Megapascal
mm	Millimetre
μm	Micrometre
kN	Kilo newton
N/mm^2	Newton per millimetre square

LIST OF ABBREVIATIONS

Al_2O_3	Aluminium Oxide
ASTM	America Standard For Testing And Material
BS	British Standard
C_3A	Tricalcium Aluminate
CaO	Calcium Oxide
HPC	High Performance Concrete
MgO	Magnesium Oxide
OPC	Ordinary Portland Cement
OPS	Oil Palm Shell
HPC	High Performance Concrete
HRWR	High-Range Water Reducer
POC	Palm Oil Clinker
Plain-UHPC	Plain Ultra-High Performance Concrete
POC-UHPC5	Ultra High Performance Concrete With 5% Palm Oil Clinker As Parti Replacement Of Coarse Aggregate.
POC-UHPC10	Ultra High Performance Concrete With 10% Palm Oil Clinker As Par Replacement Of Coarse Aggregate.
POC-UHPC15	Ultra High Performance Concrete With 15% Palm Oil Clinker As Partial Replacement Of Coarse Aggregate.
SO_3	Sulfur Trioxide
UHPC	Ultra High Performance Concrete
w/c	Water to Cement Ratio

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In the world, the production of concrete has increasing every year. It was estimated that the world consumes twenty-five billion tonnes of concrete every year (Kumar et al., 2017) . Concrete were used in construction field for various purpose such as for structural, highway and other. Concrete also known as the second most consumed material after water (Kumar et al., 2017).

The development in mineral admixture and chemical admixture have lead to the introduction of several type of high quality concrete (Alsalman et al., 2017). The high quality concrete is high strength concrete and high performance concrete. (Alsalman et al., 2017) also stated that, the further advancement in concrete technology has found a new type of concrete which is ultra-high performance concrete. Ultra-high performance concrete is a concrete that has compressive strength up to 100 MPa and high tensile strength. It is relatively new building material that has superior mechanical strength, ductility, impact resistance, fatigue resistance and durability (Li et al., 2018). In general, UHPC content of cementitious component such as Ordinary Portland cement, quartz powder, quartz sand, super plasticizer and fibers (Shi et al., 2015).

Other than the properties of ultra-high performance concrete, it has some limitations in terms of cost and accessibility of raw materials. The development of more durable and sustainable concrete in order to decrease life cycle cost of structures is in important trend in modern civil engineering (Janković et al., 2016). The production of UHPC require high amount of money which it is designed with a high content of powder as stated by (P. P. Li et al., 2018). Thus it becomes the greatest challenges to construction world due to the depletion of raw materials especially natural resource.

(Ambily et al., 2015) stated that depletion of natural resources at the same time new by products are being generated by various industries which could have a promising future in construction industry as partial or full substitute of either cement or aggregate. Natural aggregate also not only costly, but the production of it can cause environmental problem such as pollution and health problem to the human. Since it is a part of material used in the production of UHPC, it gives the idea to the researcher to find the alternative to replace fully or partially natural aggregate.

Malaysia had produced a various type of waste from a different industry such as bottle, glass, roof tiles, seramic, palm oil clinker and other. This type of waste has contributed to the environmental problem and been issued all around the world. Palm oil waste is one of the significant wastes that should be more concerned. Since Malaysia is the second largest palm oil producing country in the world, it expected that the waste produce from palm oil industry will be growth due to the on-going global consumption demand for palm oil (Abutaha et al, 2016). Usually the waste that is produce will be dumped off to sites and will lead to environmental pollution (Abutaha et al, 2018) . However, (Ibrahim et al, 2016) stated various studies has been shows that this waste can serve as potential construction materials and by this way it can reduce environmental problem before.

Several studies have been reported by previous researchers on possibility of the use of palm oil clinker as replacement material in concrete production. It was found that the palm oil clinker is suitable used to produce lightweight concrete if it is crush into desired size (Mohammed et al, 2014). Even POC will give the reduction in compressive strength and flexural strength, it still suitable to be used as the part of material replacement in concrete mix.

The studies regarding of palm oil clinker in concrete are abundant, but there is not much study regarding the incorporation of coarse aggregate as a material in ultra-high performance concrete. Therefore, the exploration on the performance of ultra-high performance concrete incorporating palm oil clinker as coarse aggregate replacement was conducted in the present study. In order to determine the performance of palm oil clinker on UHPC, the mechanical properties of a plain UHPC and the series of POC-UHPC were investigated.

1.2 Problem Statement

Malaysia is a one of developing countries in construction. They have their own production of cement and aggregate. The requirement of aggregate for the production of concrete require huge used of natural stone material. Due the high demand for production of aggregate, it has causes various issue especially in environmental problem. The environmental problems that happen caused by the production of coarse aggregate are getting worse. This production can cause environmental problem such as air pollution, noise pollution, destroy ecological balance and can cause global warming (Ismail et al., 2013). It also can easily affect the human being health through respiration system where they will inhale the fine particle produce by quarry process.

From the issue that arises, previous researchers have found the solution to overcome the problem in order to save the environment and human being. They were concentrate on the use of waste materials in construction industry especially in concrete production (Serniabat et al., 2014). In Malaysia, the production of palm oil in 2016 is around 17,320,000 tonnes a year (Varqa S. , 2017). Imaging that the wastage from palm oil industry is huge for a year. The wastage that produced via this production can be used as coarse aggregate in concrete namely palm oil clinker. This was proven through the study by (Abutaha et al., 2016b) on the use of palm oil clinker as partially replace of natural aggregate in concrete production. Thus, the consumption of natural aggregate can be reduced along with the environmental problem.

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